REMARKS

By this Amendment, Claims 1, 4, 24 and 25 have been amended, and new Claims 26 and 27 have been added, leaving Claims 1-4, 6-12 and 14-27 pending in the application. The amendments to Claims 1 and 4 do not narrow their scope. The amendments to Claim 1 make explicit subject matter that was already implicit in this claim. Reconsideration of the June 21, 2004, Official Action is respectfully requested in light of the above amendments and the following remarks.

Allowable Subject Matter

Applicants gratefully acknowledge the indication at numbered paragraph (4) of the Official Action that Claims 24 and 25 contain allowable subject matter. Claims 24 and 25 have been rewritten in independent form including the combinations of features of Claim 1 (prior to this Amendment) and Claims 24 and 25, respectively, and thus are allowable. For the reasons stated below, however, all pending claims are patentable.

First Rejection Under 35 U.S.C. § 103

Claims 1-4, 6-12 and 14-23 stand rejected under 35 U.S.C. §103(a) over U.S. Patent No. 6,174,451 to Hung et al. ("Hung") in view of U.S. Patent No. 6,074,959 to Wang et al. ("Wang") and U.S. Patent No. 6,228,438 to Schmitt "as evidenced by" U.S. Patent No. 6,451,157 to Hubacek. The reasons for this rejection are stated on pages 3-7 of the Official Action. The rejection is respectfully traversed.

Claim 1, as amended, recites a method of etching a dielectric layer with selectivity to an underlying stop layer, comprising "supporting a semiconductor substrate in a plasma etch chamber of a plasma etch reactor, wherein the plasma etch reactor is a capacitively coupled plasma reactor having a powered showerhead electrode and/or a powered bottom electrode, the substrate including a dielectric layer over a stop layer; supplying an etchant gas to the plasma etch chamber with the showerhead electrode; and etching openings in the dielectric layer by energizing the etchant gas into a plasma state by capacitively coupling RF energy into the plasma etch chamber, the etchant gas comprising a hydrogen-free fluorocarbon gas represented by C_xF_y gas wherein $y/x \leq 1.5$, an oxygen-containing gas and optional carrier gas" (emphasis added).

The subject matter recited in Claim 1 has been clarified in view of the assertion in the Official Action that "apparatus limitations do not have weight in [a] process claim, unless they affect the process in a manipulative sense." As stated, for example, in Leesona Corp. v. United States, 185 USPQ 156, 165 (Ct. Cl. Trial Div. 1975), "it is generally the rule that patentability of a method claim must rest on method steps recited, not on the structure used, unless the structure affects the method steps" (emphasis added). To further clarify that the recited capacitively coupled plasma reactor "affects the method steps" of the claimed method, Claim 1 has been amended to recite the method features of "etching openings in the dielectric layer by energizing the etchant gas into a plasma state by capacitively coupling RF energy into the plasma etch chamber" (emphasis added). Applicants

submit that these recited features must be given weight in the determination of the patentability of Claim 1.

In addition, to further clarify that the recited showerhead electrode "affects the method steps," the subject matter recited in Claim 1 has also been clarified to recite the features of "supplying an etchant gas to the plasma etch chamber with the showerhead electrode." Applicants submit that these features must also be given weight in the determination of the patentability of Claim 1.

Regarding the stated reasons for the rejection, the Official Action asserts that Hung discloses a method of etching a dielectric layer, e.g., an oxide layer, with selectivity to an underlying stop layer, such as a nitride stop layer, e.g. a SAC (self-aligned contact) structure. The Official Action further asserts that Hung discloses an etching gas that may comprise a hydrogen-free fluorocarbon gas represented by C_xF_y gas, wherein $y/x \leq 1.5$ (such as C_4F_6) and carrier gas (such as argon), and that the main etch with no CH_2F_2 may be used to etch the entire oxide layer. However, the Official Action acknowledges that Hung does not teach that an oxygen-containing gas may be incorporated in the etch gas for the oxide layer.

Regarding Wang, the Official Action asserts that this reference teaches that fluorocarbon may be used, and that Wang's process may be modified by the addition of carbon monoxide, nitrogen or oxygen, all of which allegedly are known to enhance selectivity and increase the etch stop margin. The Official Action asserts that it would have been obvious to modify Hung's etchant gas by adding oxygen as taught by Wang to allegedly enhance selectivity and increase the etch stop margin.

The Official Action also asserts that Hung discloses that the oxide etching process may use commercially available plasma reactors, and "therefore, it would have been obvious ... to use popular commercial available plasma reactors" (emphasis added).

The Official Action states that Schmitt is relied on solely as an alleged teaching of one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode. The Official Action further alleges that it would have been obvious to use the "popular commercial available plasma reactors as disclosed by Schmitt in the process of Hung and Wang in order to provide their art recognized advantages and produce an expected result."

Hubacek has been cited as "evidence" to allegedly show that a showerhead arrangement can be used in any type of semiconductor processing apparatus.

Applicants respectfully disagree with the above assertions and submit that the cited references fail to support the rejection. First, Hubacek does not qualify as a prior art reference against the present application under 35 U.S.C. § 102. Particularly, the present application was filed on March 30, 2001. Hubacek was filed on September 23, 1999 and issued on September 17, 2002. Accordingly, Hubacek may appear on its face to qualify as a reference under 35 U.S.C. § 102(e). However, according to 35 U.S.C. § 103(c):

> Subject matter developed by another person, which qualifies as prior art only under one of subsections (e), (f), and (g) of section 102 of this title, shall not preclude

> patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

Hubacek and the present application are commonly assigned to Lam Research Corporation, as evidenced by the Assignments recorded at reel 010342/frame 0023 and reel 011873/frame 0705, respectively. In addition, Hubacek and the claimed subject matter were, at the time the invention was made, subject to an obligation of assignment to the same person (i.e., Lam Research Corporation). Thus, Hubacek does not qualify as a reference under 35 U.S.C. §§ 102(e), (f) or (g) pursuant to 35 U.S.C. § 103(c). Therefore, the rejection is improper for this reason.

Moreover, the combination of Hung, Wang and Schmitt fails to support any alleged *prima facie* case of obviousness regarding the method recited in Claim 1. According to MPEP § 2143, to establish a *prima facie* case of obviousness, (1) "there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to ... combine reference teachings"; (2) "there must be a reasonable expectation of success"; and (3) "the prior art ... references when combined ... must teach or suggest all the claim limitations." For reasons stated below, the cited combination of references fails to meet these requirements.

Additionally, if the proposed modification would render the prior art being modified unsatisfactory for its intended purpose, then there is no suggestion or

motivation to make the proposed modification. In re Gordon, 221 USPQ 1125 (Fed. Cir. 1984) and MPEP § 2143.01.

Hung discloses a process that uses a high-density plasma etch reactor (column 7, lines 33-48 and column 11, lines 1-10). In fact, Hung states that "[t]he high-density plasma is further important because it produces a higher fraction of ionized etching particles, which can be directed to the bottom of holes with high aspect ratio" (column 7, lines 45-48). The high-density plasma etch reactor is preferably an inductively coupled plasma etch reactor (column 11, lines 1-8).

Hung teaches away from using a capacitively coupled plasma reactor for an SAC process. Particularly, Hung discloses that:

> Fukuta has previously disclosed an oxide etching process using C_4F_6 .... However, he uses a magnetically enhanced capacitively coupled etch chamber. His structure requires selectivity only at the bottom of a via hole, and he does not address the high selectivity required for via holes in advanced processes like SAC. The capacitively coupled reactor does not allow the decoupling of the source and bias power. (Column 7, lines 6-14; emphasis added).

Furthermore, as shown in Tables 1, 2, 3 and 4 of Hung (columns 7-10), in each of Hung's examples, inner and outer source power and bias power was applied during etching of SAC structures. Consistent with Hung's disclosure that a capacitively coupled plasma reactor does not allow the decoupling of source and bias power, Hung discloses that:

> The examples reported above were obtained on the inductively coupled IPS reactor capable of producing a high-density plasma. Other inductively coupled plasma etch reactors are available with a variety of coil configurations. The current inductively coupled HDP reactors have the advantage of

> decoupling the source power from the bias power, thus allowing a reasonable etching rate with low ion energies. (Column 11, lines 1-8; emphasis added).

As noted in the Official Action, Hung discloses that:

> The oxide etching process of the invention thus provides superior etching characteristics with the use of gases which are novel to semiconductor processing but which are commercially available. The other process parameters are achievable in commercially available plasma reactors. (Column 11, lines 40-44; emphasis added).

However, Applicants submit that the Official Action has misinterpreted the intended meaning of Hung's statement that "the other process parameters are achievable in commercially available plasma reactors" in light of Hung's entire disclosure. Namely, Hung teaches away from the use of any plasma reactor that does not (i) produce a high-density plasma and (ii) allow the decoupling of source and bias power. According to Hung, a capacitively coupled reactor is one particular type of plasma reactor that does not allow such decoupling of source and bias power. Although Hung refers generally to "commercially available plasma reactors," it is clear from Hung's disclosure considered as a whole that, contrary to the assertion in the Official Action, such group of "commercially available plasma reactors" excludes capacitively coupled reactors because Hung emphasizes that such reactors are unsuitable for achieving requirements of Hung's process.

As explained in MPEP § 2141.03, "[a] prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention" (emphasis added, citations omitted). When Hung is properly considered in its entirety, including the portions that disclose capacitively coupled

plasma reactors are unsuitable for performing Hung's etching process, it is apparent that Hung would have led one having ordinary skill in the art away from the method recited in Claim 1, including the features of "etching openings in the dielectric layer by energizing the etchant gas into a plasma state by capacitively coupling RF energy into the plasma etch chamber."

Wang discloses a plasma etch process that may utilize hydrogen-containing etching gases to etch structures that may include a nitride layer. Wang discloses etch gases that have an F/C ratio of 2 or more (column 16, lines 9-19). Although Wang discloses without specificity that carbon monoxide, nitrogen or oxygen may be added to the etch gas, Wang provides no example of an oxygen-containing etch gas, much less an oxygen-containing etch gas that also contains a hydrogen-free C_xF_y gas, wherein $y/x \leq 1.5$. Accordingly, Wang provides no suggestion of modifying Hung's etch gas chemistry to incorporate an oxygen-containing gas.

Schmitt relates to a capacitively coupled RF plasma reactor. As explained above, Hung teaches away from using a capacitively coupled RF plasma reactor, as disclosed by Schmitt. As explained at MPEP § 2145(X)(D)(2) (Feb. 2003), "it is improper to combine references where the references teach away from the combination. *In re Grasselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983)." Thus, the rejection of Claim 1 is improper for this reason as well.

Furthermore, Hung and Schmitt are directed to incompatible etch processes. Namely, Hung discloses a high-density plasma process. In contrast, Schmitt discloses a capacitively coupled plasma process. Schmitt does not disclose or

suggest that the plasma reactor provides a high-density plasma. Accordingly, substituting Schmitt's plasma reactor for Hung's high-density plasma etch process would result in changing the principle of operation of Hung by using a capacitively coupled etch reactor to carry out the modified Hung etch process. Accordingly, because the proposed modification of Hung would change its principle of operation, the teachings of Hung, Wang and Schmitt are not sufficient to render the claimed subject matter *prima facie* obvious. See In re Ratti, 123 USPQ 349 (CCPA 1959) and MPEP § 2143.01.

The Official Action also has failed to establish the required reasonable expectation of success for the asserted modification of Hung because Hung's process needs to use (i) a high-density plasma and (ii) decoupling of source and bias power.

Additionally, the proposed modification to Hung, using the capacitively coupled RF plasma reactor of Schmitt, renders Hung unsatisfactory for its intended purpose. Thus, there is no suggestion or motivation to make the proposed modification.

Hung, Wang and Schmitt also fail to suggest modifying Hung's process to include the step of "supplying an etchant gas to the plasma etch chamber with the showerhead electrode," as recited in Claim 1. The Official Action has improperly relied on Hubacek to allegedly cure the deficiencies of the other references with regard to these claimed features.

Therefore, Claim 1 is patentable over the cited references. Claims 2-4, 6-12 and 14-23 depend from Claim 1 and thus also are patentable. Furthermore, these dependent claims recite additional combinations of features that further patentably distinguish the claimed method over the cited references.

Regarding Claims 7 and 8, for example, the Official Action acknowledges that "[t]he combined prior art does not disclose the flow rate of oxygen (O_2) for the process," but alleges oxygen is a result-effective process variable. Claim 7 recites the feature of "the etchant gas is nitrogen-free, the C_xF_y gas is at least C_4F_6, the oxygen containing gas is at least O_2 and the carrier gas is Ar, the etchant gas being supplied to the plasma etch reactor through the showerhead electrode at flow rates of 2 to 50 sccm C_4F_6, 2 to 50 sccm O_2 and 50 to 800 sccm Ar." Claim 8 recites the features of "the C_xF_y gas is at least C_4F_6, the oxygen containing gas is at least O_2 and the carrier gas is Ar, the etchant gas being supplied to the plasma etch reactor through the showerhead electrode at flow rates of 10 to 25 sccm C_4F_6, 5 to 20 sccm O_2 and 50 to 300 sccm Ar."

Wang does not suggest the addition of oxygen to a hydrogen-free fluorocarbon gas represented by C_xF_y, wherein $y/x \leq 1.5$, much less to achieve a recognized result. Thus, in light of Wang, the amount of oxygen to add is clearly not a known result-effective variable. See In re Antonie, 195 USPQ 6 (CCPA 1977). Accordingly, Claims 7 and 8 are further patentable over the cited combination of references.

Therefore, withdrawal of the rejection is respectfully requested.

Second Rejection Under 35 U.S.C. § 103

Claims 1-4, 6-12 and 14-23 stand rejected under 35 U.S.C. §103(a) over U.S. Patent No. 5,366,590 to Kadomura ("Kadomura") in view of Wang and Schmitt, "as evidenced by" Hubacek. The reasons for this rejection are stated on pages 7-11 of the Official Action. The rejection is respectfully traversed.

The Official Action asserts that Kadomura discloses a method of etching a dielectric layer with selectivity to an underlying stop layer, where a substrate that is etched can include a dielectric layer (e.g., an oxide layer) over a nitride stop layer. The Official Action further asserts that the etchant gas may comprise a hydrogen-free fluorocarbon gas represented by C_xF_y gas, wherein $y/x \leq 1.5$, such as C_4F_6 or C_6F_6. The Official Action also asserts that Kadomura discloses that the oxide etching process with the nitride stop layer may use commercially available plasma reactors. However, the Official Action acknowledges that Kadomura does not disclose that an oxygen-containing gas may be incorporated in the etchant gas for the oxide layer.

The Official Action alleges that it would have been obvious to modify the etchant gas of Kadomura by adding oxygen as taught by Wang.

The Official Action states that Schmitt is relied on solely as an alleged teaching of one of the popular commercial available plasma reactors with dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode. The Official Action further alleges that it would

have been obvious to use the "popular commercial available plasma reactors" as disclosed by Schmitt in the process of Kadomura and Wang "in order to provide their art recognized advantages and produce an expected result."

Hubacek has been cited as "evidence" to allegedly show that a showerhead arrangement can be used in any type of semiconductor processing apparatus.

Applicants respectfully disagree with the above-described assertions and submit that the cited references fail to support the rejection. First, because Hubacek does not qualify as a reference under 35 U.S.C. § 102(e), (f) or (g) against the present application, the rejection is improper.

Furthermore, the combination of Kadomura, Wang and Schmitt fails to suggest the combination of features recited in Claim 1 and the claims dependent therefrom. Kadomura discloses a process that uses a high-density plasma etch reactor (column 3, lines 36-44). In fact, Kadomura specifically discloses that the fluorocarbon etching gas is in the form of a high-density plasma because of dissociation that takes place more readily than in the case of conventional RF plasma under a low pressure (Column 4, lines 53-58).

In contrast, Schmitt discloses a capacitively coupled RF plasma reactor, which Schmitt does not disclose or suggest provides high-density plasma. Thus, the Official Action has failed to establish the necessary motivation to modify Kadomura to incorporate selected, incompatible teachings from Schmitt. For reasons stated above, such modification would change the principle of operation of Kadomura and thus the combined teachings of Kadomura, Wang and Schmitt are not sufficient to

render the method of Claim 1 *prima facie* obvious according to the provisions of MPEP § 2143.01.

The Official Action has also failed to establish the required reasonable expectation of success resulting from the asserted modification of Kadomura.

Kadomura, Wang and Schmitt also fail to suggest modifying Hung's process to include the step of "supplying an etchant gas to the plasma etch chamber with the showerhead electrode," as recited in Claim 1. The Official Action has improperly relied on Hubacek to allegedly cure the deficiencies of the other references with regard to these claimed features.

Therefore, the method recited in Claim 1 is patentable over the cited combination of references. Claims 2-4, 6-12 and 14-23 depend from Claim 1 and thus also are patentable. Furthermore, these dependent claims recite additional combinations of features that further patentably distinguish the claimed method over the cited references. As explained above, Wang and Schmitt fail to suggest the addition of oxygen to a hydrogen-free main etchant gas represented by C_xF_y, wherein $y/x \leq 1.5$, to achieve a recognized result, and thus fail to suggest that the amount of oxygen to add is a known result-effective variable. Accordingly, Claims 7 and 8 are patentable over the cited combination of references.

New Claims

Claim 26 depends from Claim 1 and recites the features of "the etchant gas is free of hydrogen-containing fluorocarbon gas." Claim 27 depends from Claim 1 and

recites the features of "the etchant gas is free of fluorocarbon gas represented by C_xF_y, wherein y/x > 1.5." Support for the subject matter recited in Claims 26 and 27 is provided, for example, in paragraphs [0041] and [0042] of the specification.

Regarding Claim 26, Wang, for example, does not suggest adding an oxygen-containing gas to an etching gas that is free of hydrogen-containing fluorocarbon gas and wherein the etching gas contains a hydrogen-free fluorocarbon gas represented by CxFy gas, wherein $y/x \leq 1.5$. Regarding Claim 27, Kadomura, for example, discloses that the etching gas is a mixture of equal amounts of C_6F_6 and CF_4 to inhibit the formation of carbon polymer (column 5, lines 14-25). Thus, Kadomura's etching gas comprises a fluorocarbon gas represented by C_xF_y, wherein y/x > 1.5. Claims 26 and 27 also are patentable.

Conclusion

In view of the foregoing, the application is in condition for allowance and such action is earnestly solicited. Should the Examiner desire to discuss any aspect of this application, the undersigned attorney can be reached at the telephone number given below.

Respectfully submitted,

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